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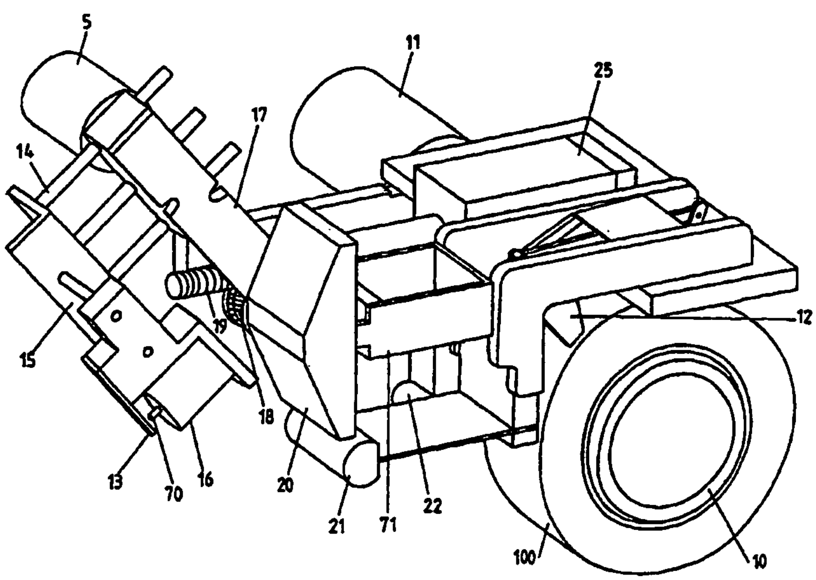
(54) Title: IMPROVEMENTS RELATING TO APPLICATION OF ADHESIVE TAPE



(57) Abstract

A tape applicator device capable of drawing adhesive tape from a roll (100) without direct human intervention. The device incorporates sensors which locate an end edge of the tape on the roll and position a blade which lifts the edge for gripping. The device also holds the roll, pulls the tape and presses it to an object surface, and cuts through the tape after each discrete portion of tape is applied to the surface. Typically the device will be mounted as an end effector unit on a robot arm under control of a general purpose micro controller. The method of operation followed by the device reduces damage to the tape while lifting the end edge and while pulling tape from the roll.

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IMPROVEMENTS RELATING TO APPLICATION OF ADHESIVE TAPE

FIELD OF THE INVENTION

This invention relates broadly to automated taping of objects such as packages, whiteware and automobile components, and cables. More specifically the invention relates to applicators which can locate and lift an end from a roll of adhesive tape and apply tape to an object without direct human intervention.

BACKGROUND OF THE INVENTION

Some automatic tape applicators are known, such as the devices described in US patent 5,192,385 for dispensing variable lengths of tape, or AU patent 307681 for applying L-clips to containers, both in the name of Minnesota Mining and Manufacturing Company (3M). None are able to lift a fresh tape end from a roll, and rely on an existing uplifted end maintained from a previous cutting operation or initiated by a human operator. Starting new rolls or restarting after a break has therefore generally involved inefficient manual processes in conjunction with otherwise automated machines.

Handling adhesive tape also requires some sensitivity to characteristics of the tape itself. The maximum rate for pulling tape from a roll without breakage decreases with temperature due to an increase in binding strength of the adhesive. The tape may be scarred or torn by careless treatment, particularly when prising a fresh end from a roll using a hard blade or similar means to locate and lift an irregular edge. Machines have generally lacked sufficient sensitivity to prevent breaking or scarring in automatic applicator operations.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide for improved machine controlled application of adhesive tape on a range of objects, or at least to provide the public with a useful choice.

The invention includes an applicator device for use in an automated tape application system. Typically the device will be an "end effector" carried by a general purpose robot arm, both of which are controlled by a programmable micro controller unit. The invention also includes methods which the applicator device may be controlled to carry out.

The device incorporates several components which cooperate to automatically draw tape from a roll. Namely means for holding and rotating the roll, means for locating an end edge of the tape on the roll, means for lifting the end edge from the roll, means for gripping the end edge and pulling tape from the roll, means for applying the tape to an object to ensure proper contact of the adhesive, and means for cutting through the tape once an application sequence has been completed. The preferred form which these components take will be described.

Equivalents of these parts or features which are not expressly set out are nevertheless to be deemed included.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment will be described as an example of the invention with respect to the following schematic drawings in which:

Figure 1 shows a prototype tape applicator device in perspective,

Figure 2 shows the applicator as tape is pulled from a roll,

Figure 3 shows the applicator in position for applying tape to an object,

Figure 4 shows the applicator applying tape to a flat horizontal surface,

Figure 5 shows a number of optical sensors positioned for locating a tape edge,

Figure 6 shows a blade and clamp holding a freshly lifted tape end,

Figure 7 shows a load sensor for monitoring tension in a tape during testing or application to an object,

Figure 8 shows a cutting mechanism which severs tape from the roll after each discrete portion of tape is applied,

Figure 9 shows a clutch mechanism by which the roll of tape is rotated only when required,

Figure 10 shows a holding mechanism for the roll while the applicator is in operation,

Figures 11a and 11b show an edge lifting blade approximately actual size,

Figures 12a and 12b show a buffer roller for pressing tape to an object,

Figures 13a and 13b show an alternative solid material buffer, and

Figure 14 is a flowchart indicate overall operation of the applicator on a robot arm.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings it will be appreciated that the applicator device is still in prototype form and that some refinement of the various components and their configuration may yet take place. Nevertheless the central features relating to automatic location and lifting of a tape end from a roll will be apparent to a skilled reader along with other aspects of the invention.

It will also be appreciated that the various motors and rams which actuate an applicator device are generally of standard design and are operated by a programmable logic controller or micro controller which need not be described in detail. The applicator is also normally to be used as an "end effector" on an otherwise general purpose robot arm which may be programmed to position and move the applicator appropriately in relation to objects on a production line.

Figure 1 is a perspective view showing a prototype applicator with a full roll of adhesive tape in place. Various components of the applicator are configured on an aluminium framework having several possible structures. A roll 100 is received on a mandrel 10 which is rotated through a clutch by motor/gearbox 11. The roll may be held on the mandrel by various means such as tapering, spring loading or a force fit. The clutch and a preferred mechanism for holding the roll securely will be described later.

Empty rolls are preferably replaced automatically from a batch of standard stock such as available from 3M. Fresh rolls will be placed nearby the production line for pickup by the applicator from the end of the robot arm. The tape material typically includes a metallic layer for enhanced strength or thermal conductivity, supplied on a roll having a diameter of about 8cm and a width of about 5cm. A maximum breaking tension of about 250N at room temperature is typically stated.

A retractable sensor device 12 is able to scan the outer surface of a slowly rotating roll to automatically locate an end edge of the tape as will be described later. A range of sensor types including magnetic proximity or even tactile devices might be used to detect roughness created by the edge, but optical back scattering sensors are preferred. These are commonly known as diffuse scan opto-switch sensors. The sensor device may also be moved toward the mandrel as tape is removed from the roll, or away when a roll is replaced.

An edge lifting device 13 is automatically positioned in proximity to the tape surface by rods 14 moved by motor 5, and pistons 15 perpendicular to rods 14 moved in respective pneumatic cylinders all mounted on a pivoting arm 17. A range of lifting devices might be used to raise a fresh edge from the roll, such as multiple blades or pneumatic cups, although a single blade is preferred and will be described later. Distance between the blade and the roll may be sensed by an inductive proximity sensor (hidden) when using metallic tape.

A clamping device 16 takes hold of a freshly lifted tape end and is pivoted away from the mandrel on arm 17. Various devices may be used to hold the tape end but a ram 70 which clamps the tape to one side of a lifting blade has proved most effective to date and again will be described further below. The arm pivots about a worm gear 18, driven by ram 25 through rake 19, and also carries rams 14, 15 and the edge lifting device 13.

A buffer 20 is used to apply tape to an object as the applicator is positioned and moved by a robot arm. The buffer may be a shaped block of low friction material or may be a shaped or deformable roller, spring mounted on a bracket 71. Other means for applying pressure to one side of the tape may also be used during this operation. The tape passes first over a load sensor 21 which monitors tension to ensure that the rate of pulling

is comfortably below a breakage threshold, and is typically pulled at about 30N. A movable blade 22 or other means for cutting the tape is positioned adjacent to the buffer, and will be described later.

Figures 2, 3 and 4 show the applicator during a single taping operation. In Figure 2 an end edge has been located and lifted from the roll 100 and the tape end is held by clamping device 16 as arm 17 pivots about worm gear 18. Mandrel 10 freewheels independently of motor 11 at this stage. A short length of tape 101 is thereby pulled from the roll over the load sensor 21. In Figure 3 arm 17 has completed pivoting and the length of tape is drawn taut over buffer 20 and the load sensor.

In Figure 4 more tape has been pulled from the roll and applied to an object surface 102. One end of a robot arm 103 is shown moving the applicator in direction 104 while buffer 20 applies pressure to form a bond between the tape and the surface. In practice the applicator will have been moved backwards at first to ensure proper adhesion of the tape end released from the clamping device 16. As the operation is nearly complete blade 22 is about to move sideways and cut the tape. The applicator may then be moved forwards to ensure the last portion of tape is pressed to the object surface. Leftover tape still attached to the roll is rewound by reverse rotation of the mandrel ready to begin a subsequent operation.

Figure 5 schematically shows the relationship between sensor device 12 in Figure 1 and an end edge of a rotating tape roll. Mandrel 10 rotates roll 100 anticlockwise as shown. The device may have two but preferably three optical sensors 150 which detect changes in the intensity of light back scattered by an edge. The light may be generated by the sensors themselves or by another source. Scanning the tape surface along three parallel lines provides a sufficiently accurate picture of edge 151 which may be straight, angled or possibly V-shaped.

Figure 6 schematically shows the relationship between the lifting and clamping devices 13, 15 in Figure 1 and a freshly lifted tape end. Mandrel 10 rotates roll 100 in the same manner as Figure 5. The lifting device preferably comprises a single replaceable shaped blade 161 positioned to contact the tape surface according to scanning information determined from sensor device 12. A proximity sensor monitors distance of the blade from the roll to ensure gentle contact and reduce possible scarring of the tape. Another proximity sensor detects the presence of a tape end 151 moving over the blade. A non-stick surface should be imparted to the blade for reducing possible build-up of adhesive during repeated lifting operations. The holding device 15 preferably comprises a piston 160 which clamps tape end 151 to blade 161 after lifting of the edge has been detected. The piston may engage a slot on one side of the blade to ensure a firm grip on the tape.

Figure 7 schematically shows the relationship between load sensor 21 in Figure 1 and a short length of tape pulled from roll 100. Mandrel 10 freewheels at an appropriate speed as the tape is wound off. The device preferably comprises a flexible cantilever arm 170 fixed at one end to support 173 and mounting a second tape buffer 171 at the other. The tape is drawn approximately perpendicularly from the roll to pass over the buffers 20 and 171. Strain gauges 172 monitor deflection of the cantilever and adjust the rate at which tape is pulled from the roll appropriately. When tape is being applied to an object the rate is controlled by speed of movement of the entire applicator over the object surface, pulling from that portion of the tape between the surface and buffer 20.

Figure 8 schematically shows the positioning of a tape cutter 22 in relation to the load sensor 21 and mandrel 10. Blade 31 is attached through plate 32 to a piston 33, and projects towards tape pulled from the roll 100 over buffer 171. Movement of the blade across the tape is determined by movement of the piston within a pneumatic cylinder 34, which in turn is fastened to the applicator framework by plate 35.

Figure 9 shows a clutch mechanism through which motor 11 rotates the mandrel 10 and roll 100. The plate 41 is fixed to the motor shaft while a sliding plate 42 is rotationally fixed to the mandrel shaft. Movement of plate 42 to engage plate 41 is determined by arm 43 which is in turn attached to a piston 44. The piston moves in cylinder 45 attached to the applicator framework by plate 46. It will be understood that operation of the clutch mechanism and the various other applicator components which have been described is ultimately determined by a programmable micro controller which forms part of an overall automated tape application system.

Figure 10 is an end view of the mandrel 10 showing a possible mechanism for securely holding roll 100. A block 50 on the axis of the mandrel supports three movable legs 51. The legs pass through slots in the cylindrical body of the mandrel to engage the roll with sufficient force. When fresh or empty rolls are received or removed on the mandrel these legs are retracted but are then forced outwards to engage the roll by a pneumatic system (hidden).

Figures 11a and 11b show an edge lifting blade 13 which has been successfully tested to date. The blade has a sharpened end 73 which pushes under a tape edge as it adheres to roll 100. The end is rounded across the face of the blade to further facilitate this action. The blade is fastened to the applicator by screws or other means which pass through holes 75. The blade was constructed of high grade tool steep or spring steel and was Teflon coated to reduce accumulation of adhesive. Other blade shapes might also be successful in practice.

Figures 12a, 12b, 13a, 13b show two alternative forms for buffer 20. In Figures 12a and 12b the buffer is shown as a roller 113 mounted in a bracket 114. A recess 117 is able to accommodate the diameter of a cable which may be taped to an object surface, by way of example. Alternative shapings of the roller may be required in practice. Figures 13a and 13b show a solid buffer 118 having a recess 119 similar to recess 117 in the roller. The block is shaped so that only portions 120 in either side of the recess 119 will apply pressure to the tape. The block material is typically grey Teflon which is able to slide over the non adhesive upper surface of the tape during an application sequence.

A prototype which operates in the manner described above has been constructed and partially tested. A 12V DC motor from Radio Spares with a reduction gearbox of 130:1 was run through the clutch mechanism for rotation of the mandrel at about 20rpm in either direction. Three diffuse scan opto-switch sensors were used in parallel across the width of the tape to sense end edges. The edge lifting blade is positioned by a small DC motor 5 and a 20mm stroke/16mm bore pneumatic cylinders which control pistons 15. A 5mm stroke/12mm bore cylinder was used to clamp the tape to the blade. An 80mm stroke/10mm bore pneumatic cylinder is used to control the cutting blade 31. A 50mm stroke/32mm bore cylinder was used to pivot arm 17. A 10mm stroke/4mm bore cylinder was used to control legs 15 in the mandrel 10. A 10mm stroke/6mm bore cylinder is used to lift the edge sensors towards and away from the roll. Operation of the tape applicator and a robot arm which oriented the applicator in three dimensions was controlled overall by a Siemens SAB80C517A micro controller.

Figure 14 indicates the overall sequence of events as a portion of tape is applied to an object on a production line. This assumes the applicator shown in Figure 1 has been mounted on the end of a robot arm operated by a micro controller. A supply of fresh tape rolls is at hand for the applicator to pick up on mandrel 10 when required. Some of the rolls may be defective in having a low breaking stress and rolls from which the tape repeatedly breaks will be discarded by the applicator.

In step 200 the robot arm moves the applicator so that a roll is received on mandrel 10. Motor 11 then rotates the mandrel and roll so that the edge sensors 12 scan the outer surface of the roll in step 205. All three sensors in Figure 5 must register the edge within a given period before location of the edge is confirmed. The shape of the edge can then be approximately determined by the relative times of detection. Once the edge has been located the end lifting blade 13 pivots towards the roll on arm 17 and is positioned by rods 14 and pistons 15 in step 210. A two position adjustment of the blade across the roll has been found satisfactory but a multi-position capability is preferred to take account of a range of possible edge shapes.

Once the blade makes gentle contact with the outer surface of the roll, motor 11 rotates the roll so that the blade is pushed under the end edge in step 215. A sensor detects when the end edge passes over the blade to operate a clamp in step 220, so that the tape end is firmly gripped. In step 225 the clutch disengages the mandrel from the motor so that the roll may freewheel as tape is pulled from the roll.

Tape is pulled in step 230 by pivoting of arm 17 away from the roll, over buffer 171 which is part of load sensor 21, and over buffer 20 and which will press tape to the object surface. The applicator is moved towards the object in step 235 so that the adhesive side of the tape contacts the object and is pressed firmly in place by buffer 20. In step 240 the load sensor 21 passes an output signal to the micro controller to ensure that the robot arm is not moved too quickly during the tape application sequence. Should the tape break the applicator is able to find the resulting edge on the roll and restart the sequence at an appropriate point.

Once the sequence is complete for a particular portion of tape being applied to the object surface tape cutter 22 severs the portion from the roll in step 245. Left over tape hanging from the roll is then rewound in step 250 by reversing motor 11. Step 240 may also incorporate a backwards motion of the applicator to ensure the stretch of tape between the edge lifting means and buffer 20 is pressed onto the object surface. Step 255 may incorporate a similar step, moving the applicator forwards to ensure that the last stretch of tape between buffer 20and blade 31 is also firmly pressed onto the surface.

CLAIMS:

1. An adhesive tape applicator for use in an automated tape application system comprising:

roll holding means which receives and rotates a roll of tape,

edge locating means which detects an end edge on the roll of tape,

end lifting means which lifts the end edge from the roll,

end pulling means which grips the end edge and pulls a length of tape from the roll,

tape applying means which presses tape from the roll onto an object surface, and

tape cutting means which severs the tape from the roll once applied to the object.

2. An applicator according to claim 1 wherein the roll holding means comprises a mandrel onto which the roll is received and which can apply a torque to rotate the roll when required or can freewheel when tape is pulled from the roll.

3. An applicator according to claim 1 wherein the edge locating means comprises two or more movable light sensors which can be positioned across the tape on the roll to determine an approximate shape for the end edge.

4. An applicator according to claim 1 wherein the end lifting means comprises a movable blade which can be positioned adjacent to the end edge on the roll so that rotation of the roll pushes the blade under the end edge.

5. An applicator according to claim 1 wherein the end pulling means comprises a movable clamp which operates with the edge lifting means to take hold of the end edge once lifted and pull tape from the roll.

6. An applicator according to claim 1 wherein the tape applying means comprises a buffer over which the tape passes under tension and which is shaped or deformable to ensure firm contact of the tape with contours of the object surface.

7. An applicator according to claim 1 wherein the tape cutting means comprises a movable blade which operates on the tape between the roll holding means and the tape applying means.

8. An automated method of applying adhesive tape to an object surface comprising:
loading a roll of tape onto a rotatable holder,
locating an end edge on the tape by rotating the roll past a retractable sensor,
lifting the end edge from the tape by pushing a retractable blade between the edge and the roll,
gripping the end edge with a retractable clamp once lifted from the roll,
pulling a length of tape from the roll by moving the clamp,
pressing the tape onto the object surface with a buffer,
moving the holder and buffer relative to the object to pull and press tape from the roll onto the object according to a preprogrammed application sequence, and
severing the tape from the roll on completion of the preprogrammed sequence.

9. An automated method of lifting an end from a roll of adhesive tape comprising:
rotating the outer surface of the roll past a sensor,
sensing the location of the end edge on the outer surface,
positioning an edge lifting means adjacent to the edge, and
rotating the roll to raise the end from the roll with the edge lifting means.

10. A method according to claim 9 further comprising sensing an approximate shape of the end edge before positioning the edge lifting means.

11. A method according to claim 9 further comprising clamping the end to the lifting means.

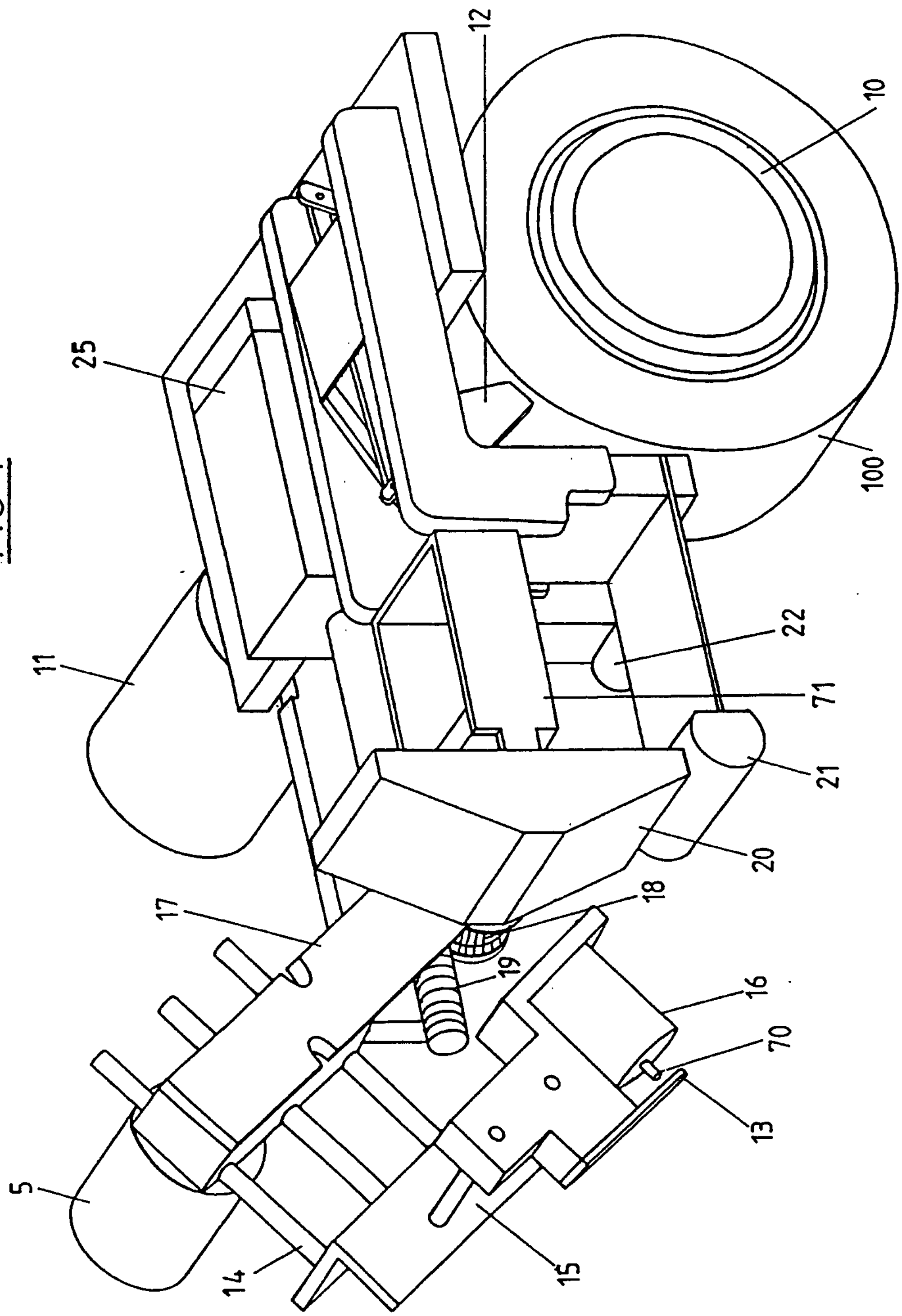


FIG 1

FIG 2

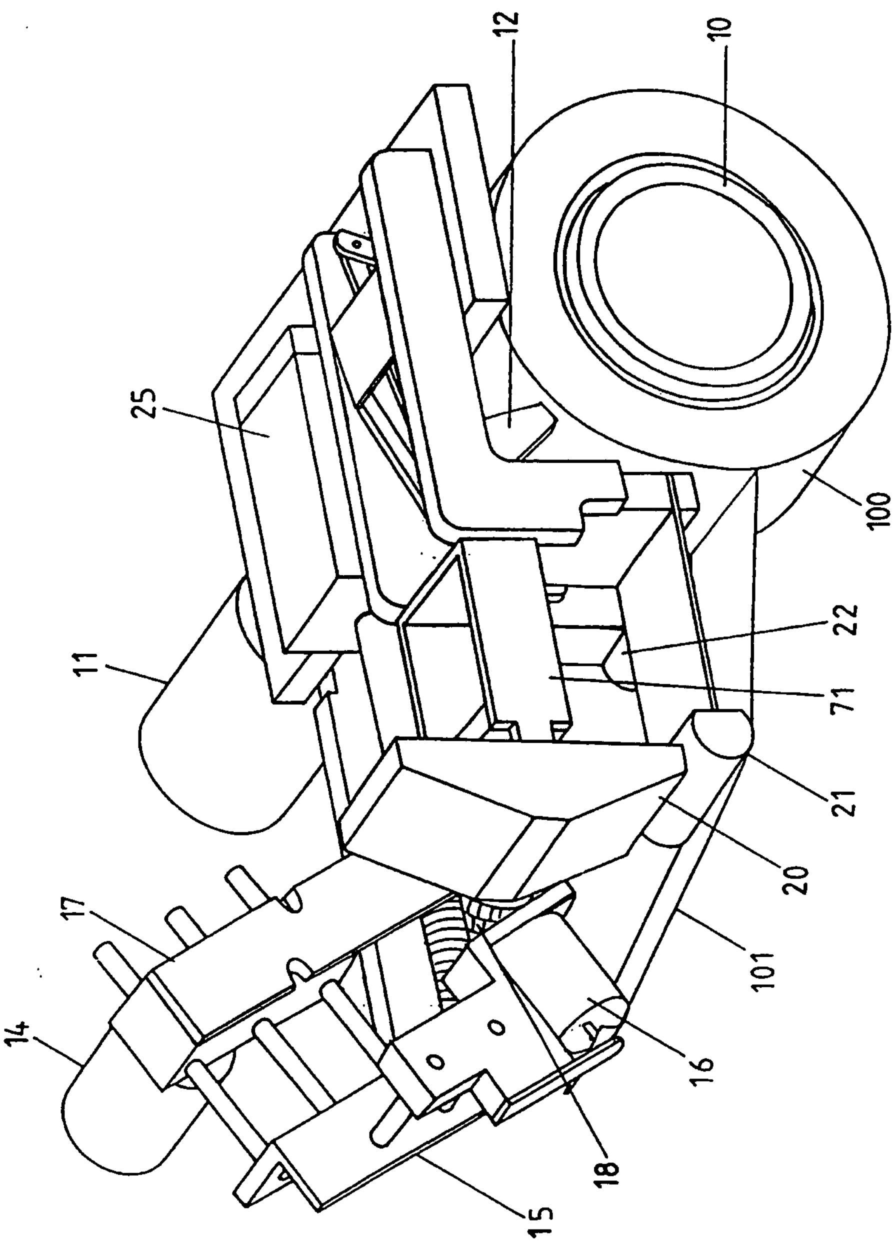
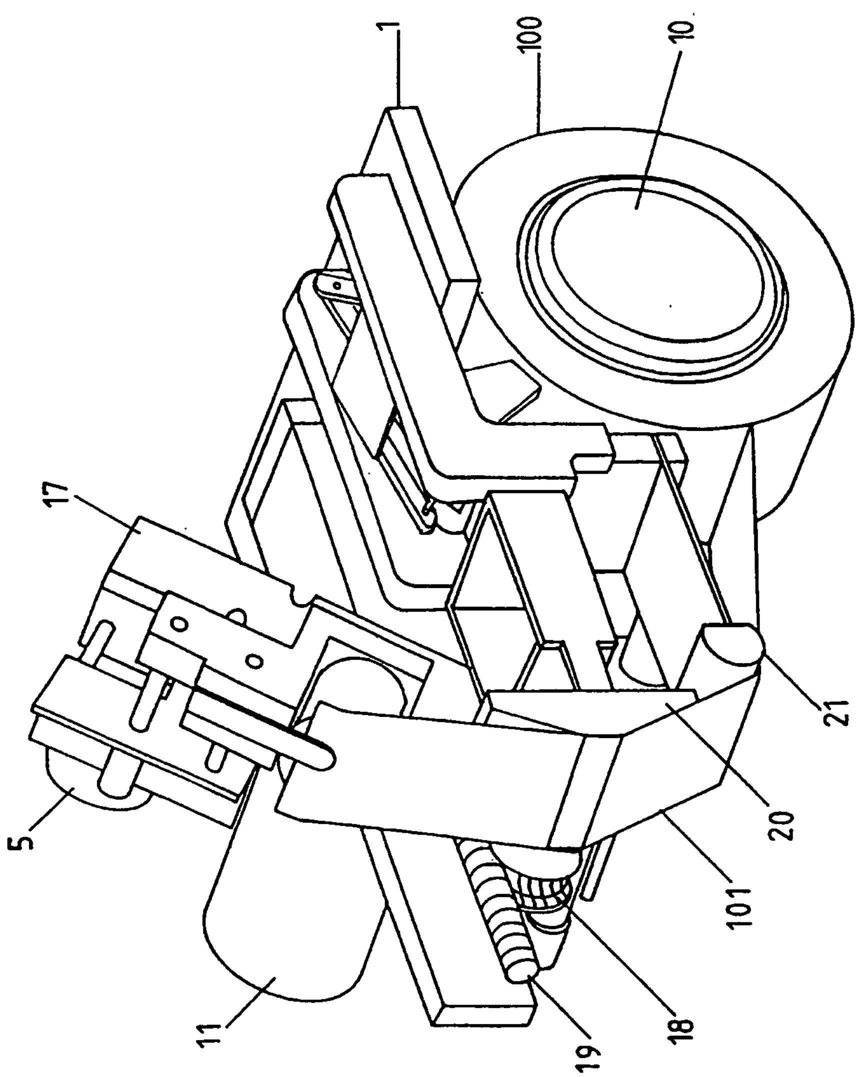


FIG 3



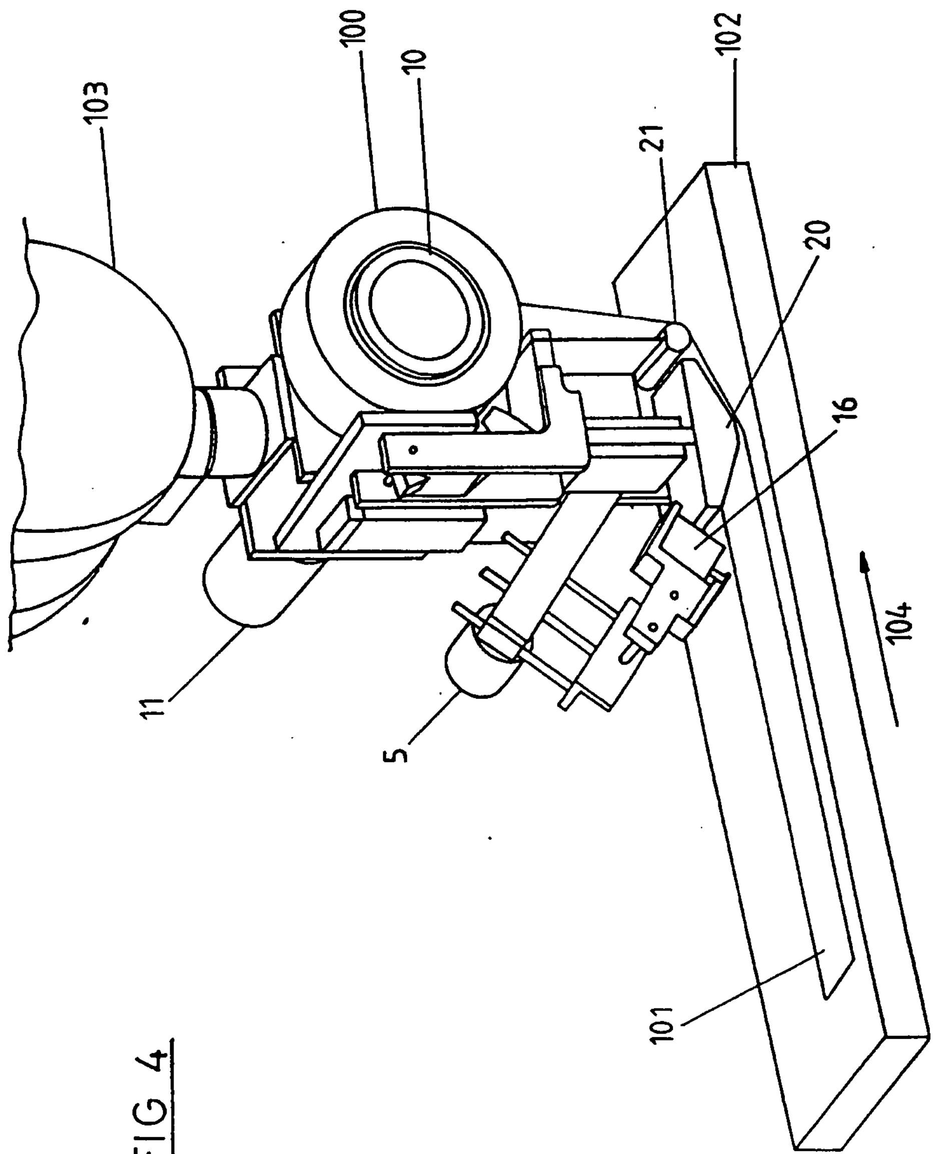


FIG 4

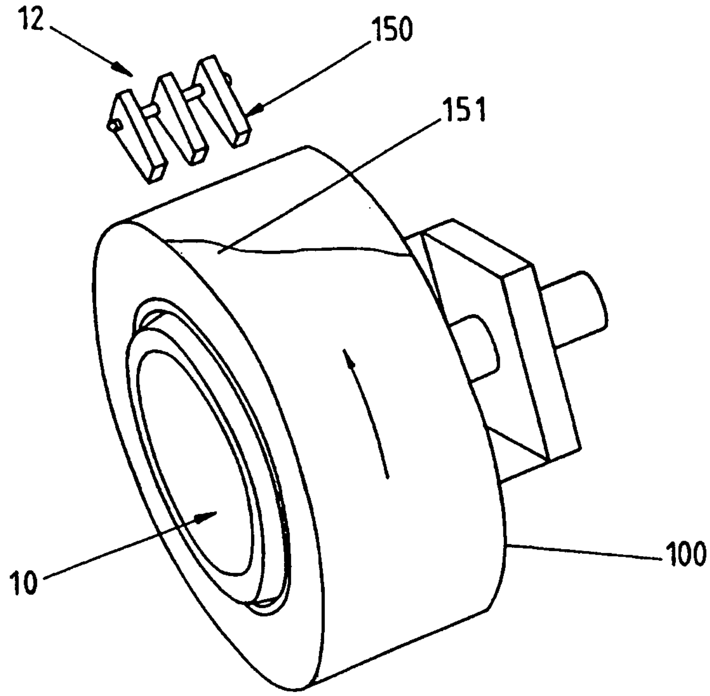


FIG 5

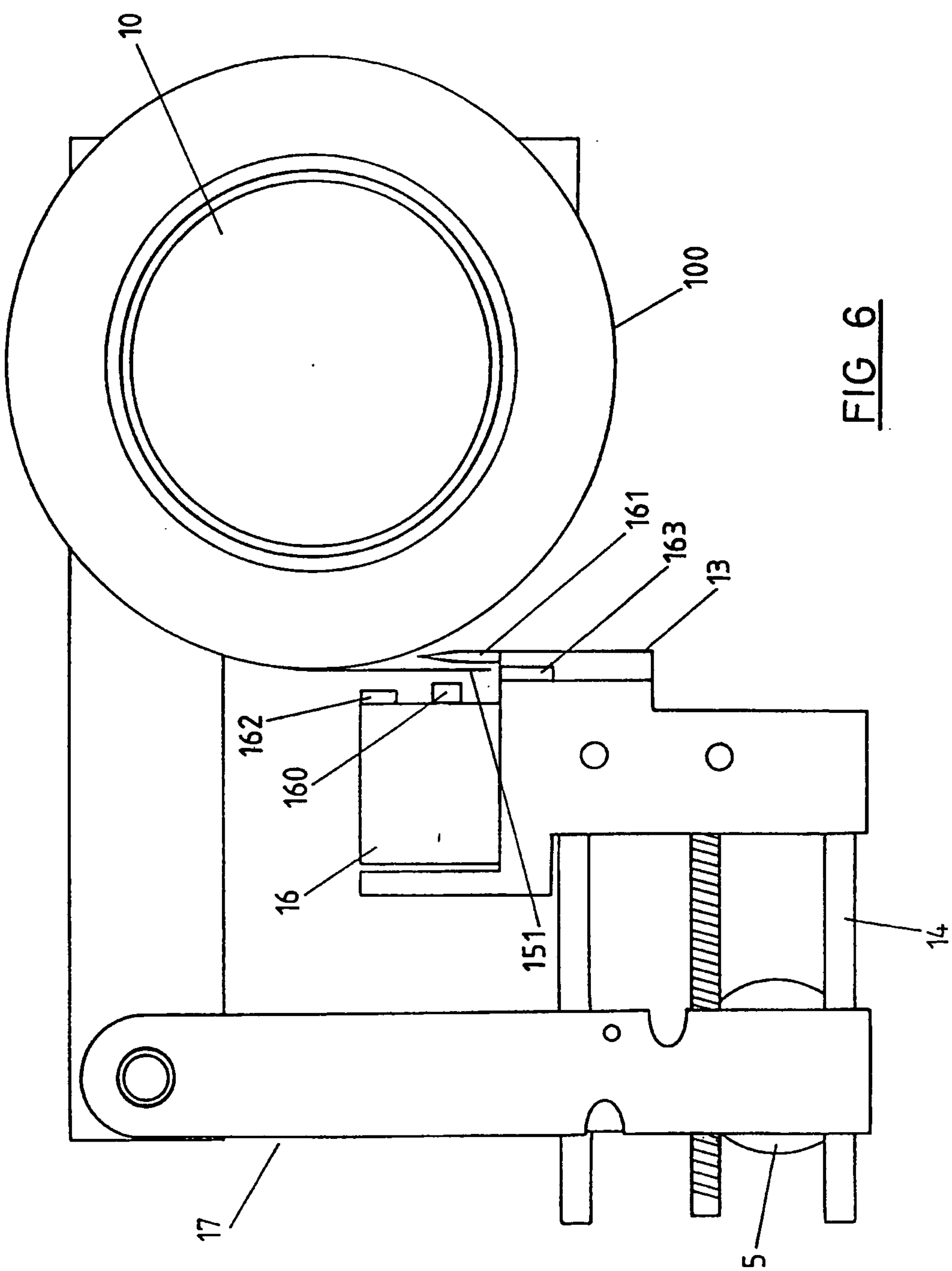


FIG 6

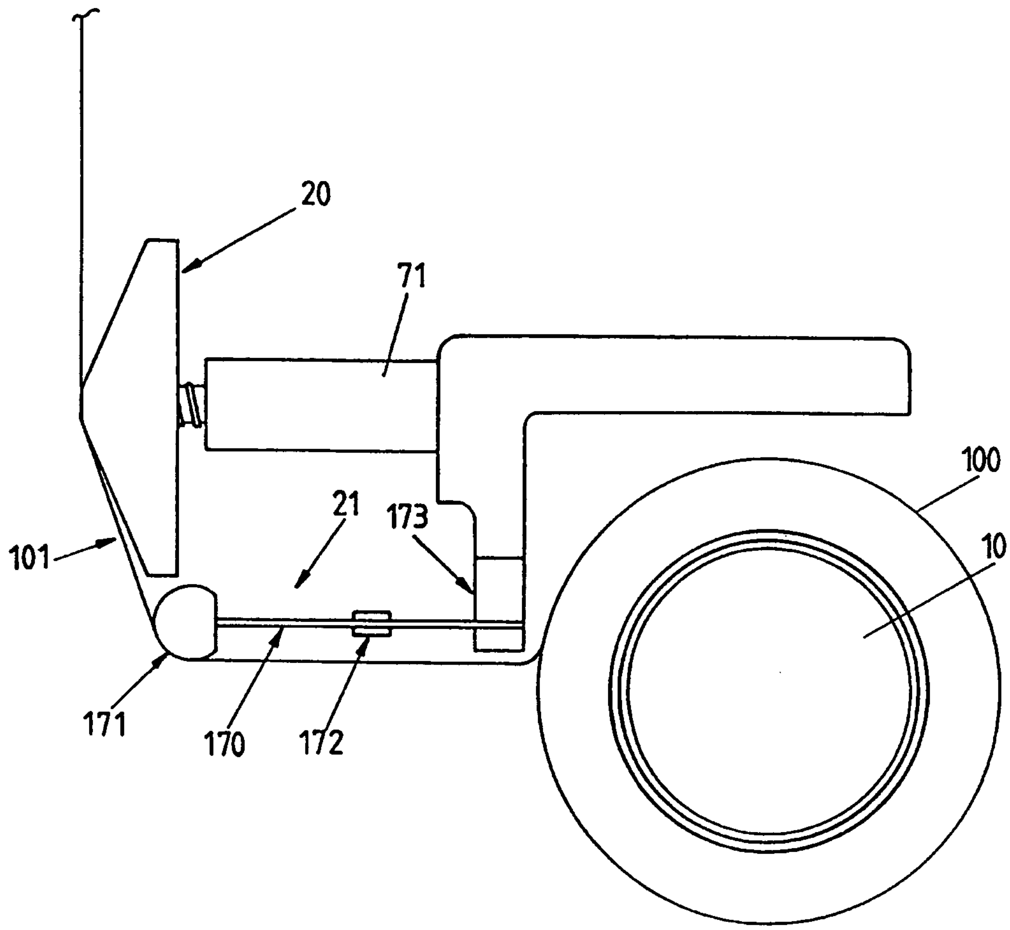


FIG 7

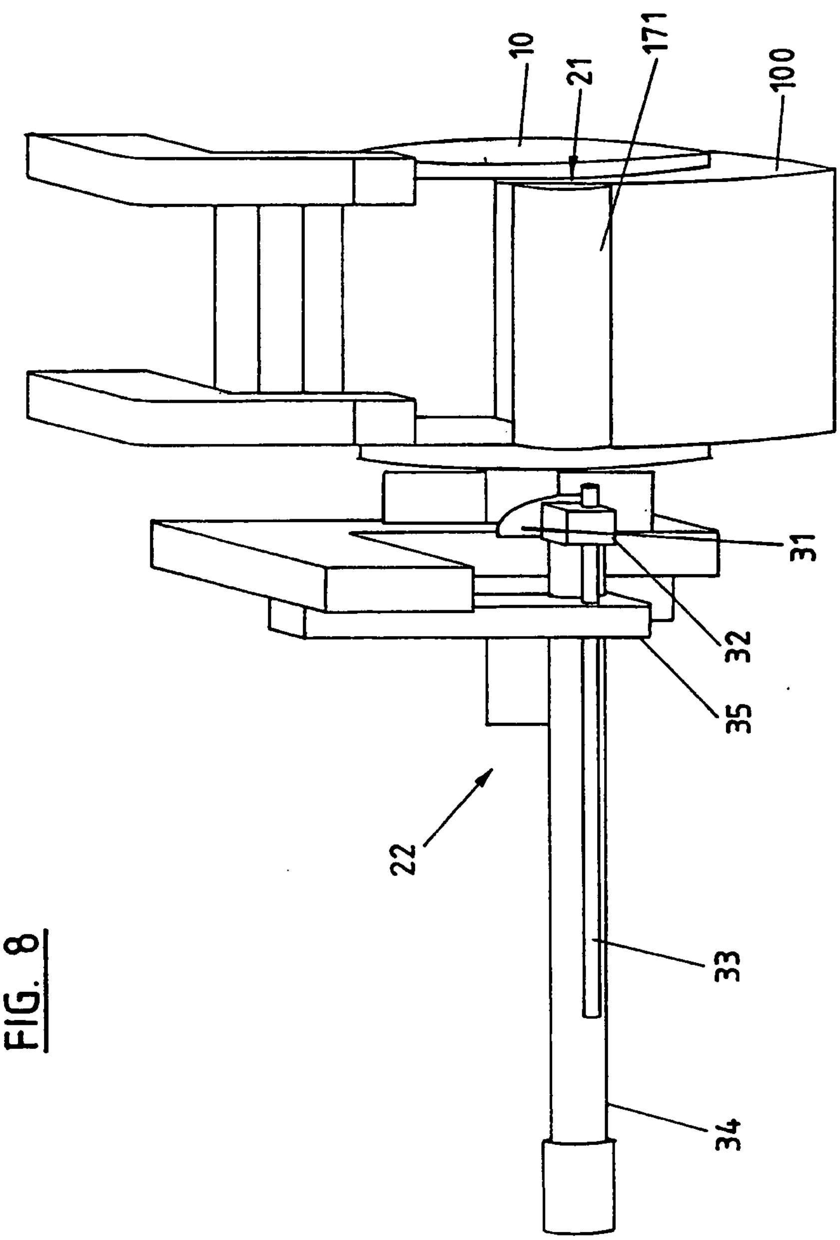


FIG. 8

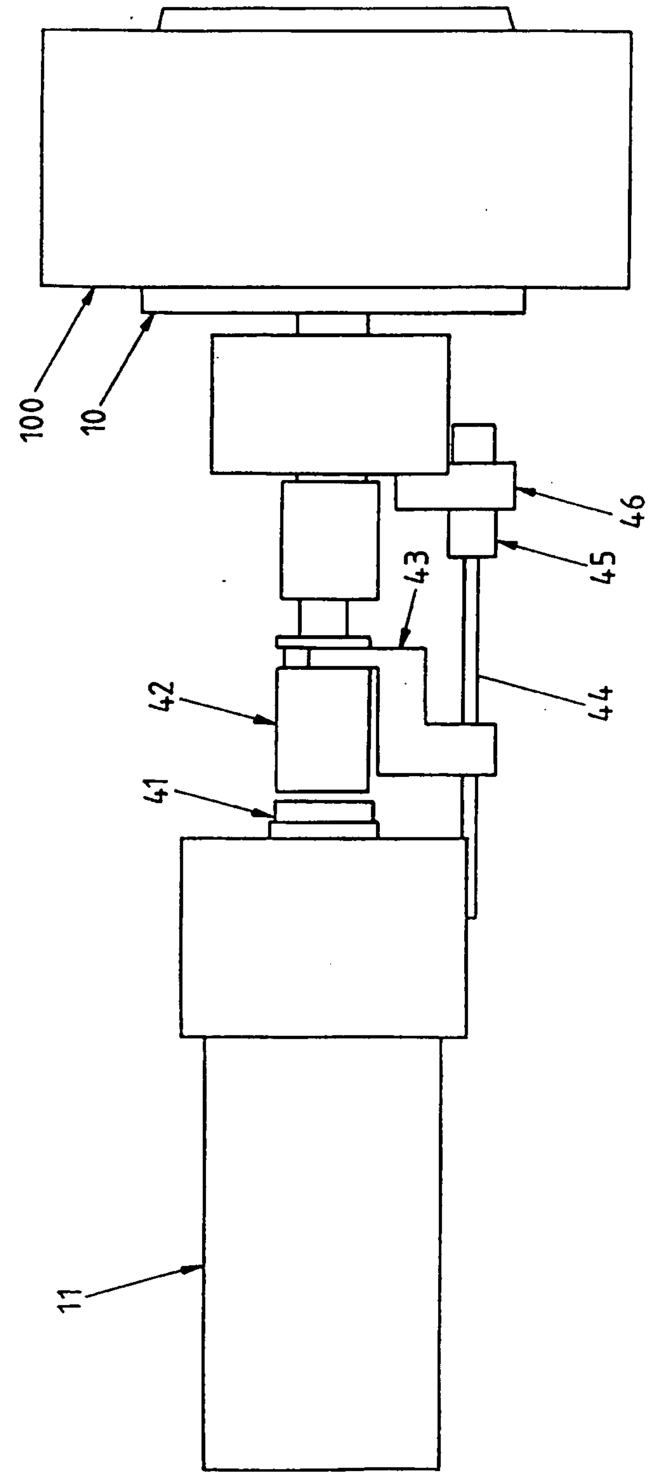


FIG 9

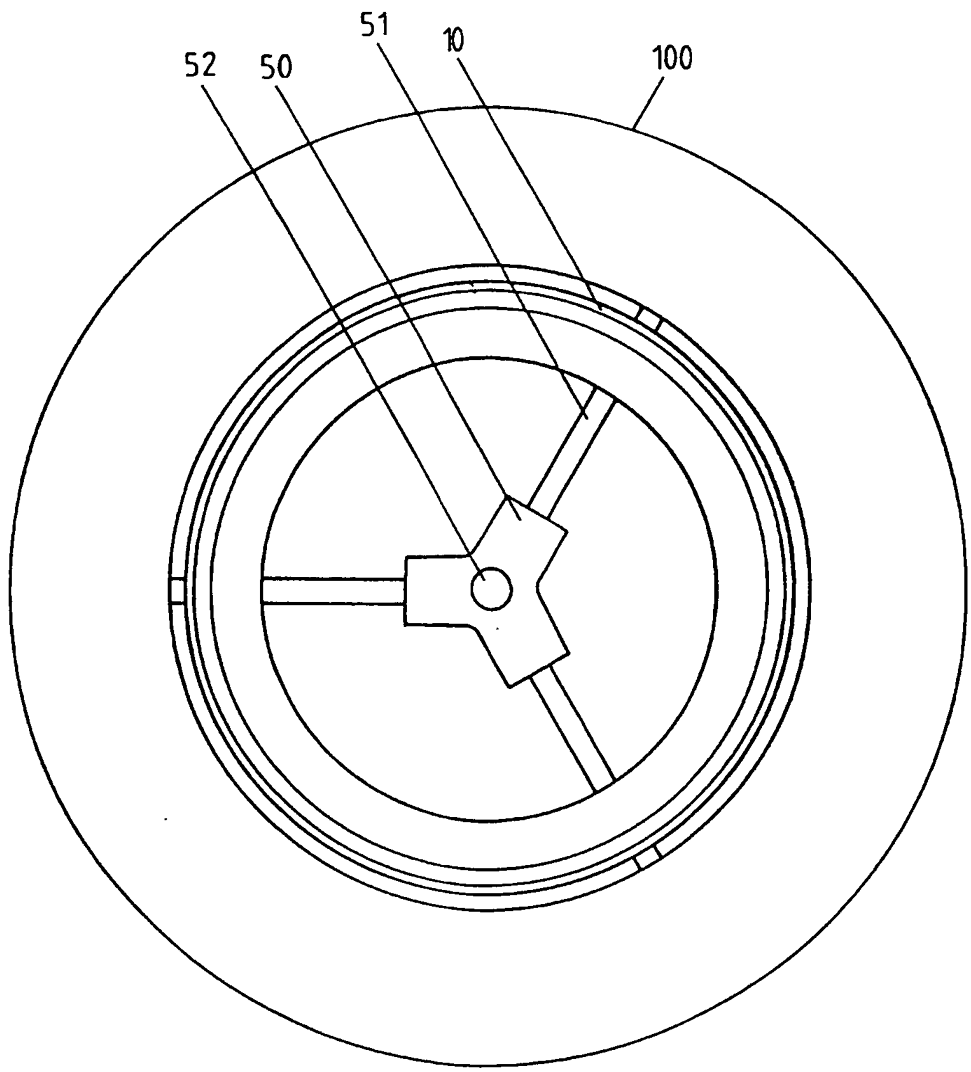
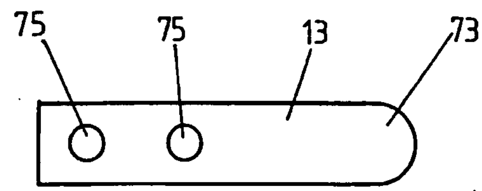


FIG 10

FIG 11a

FIG 11b



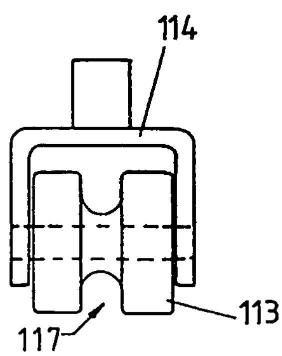


FIG 12a

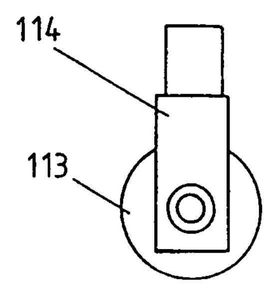


FIG 12b

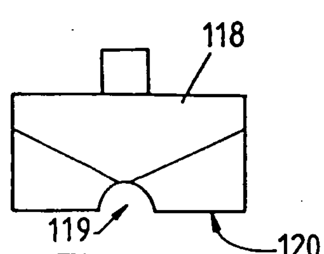


FIG 13a

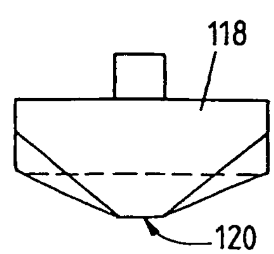
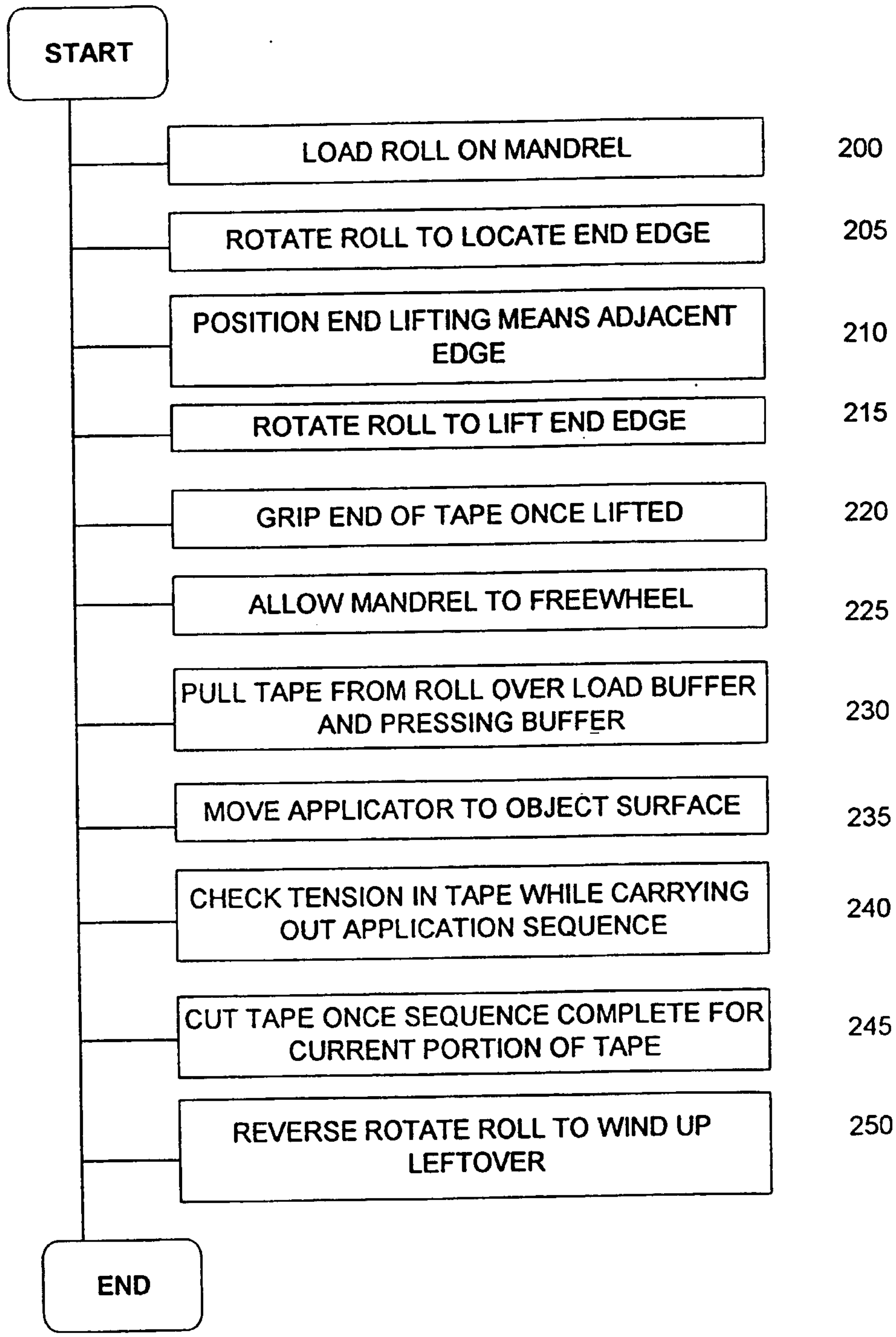


FIG 13b

FIG 14


START
LOAD ROLL ON MANDREL
200
ROTATE ROLL TO LOCATE END EDGE
205
POSITION END LIFTING MEANS ADJACENT EDGE
210
ROTATE ROLL TO LIFT END EDGE
215
GRIP END OF TAPE ONCE LIFTED
220
ALLOW MANDREL TO FREEWHEEL
225
PULL TAPE FROM ROLL OVER LOAD BUFFER AND PRESSING BUFFER
230
MOVE APPLICATOR TO OBJECT SURFACE
235
CHECK TENSION IN TAPE WHILE CARRYING OUT APPLICATION SEQUENCE
240
CUT TAPE ONCE SEQUENCE COMPLETE FOR CURRENT PORTION OF TAPE
245
REVERSE ROTATE ROLL TO WIND UP LEFTOVER
250
END

INTERNATIONAL SEARCH REPORT

Inten nal Application No
PCT/NZ 95/00032

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B65H35/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO-A-93 07063 (LA CORPORATION DES RUBANS ADHÉSIFS VIBAC DU CANADA) 15 April 1993 see the whole document	1
A	PATENT ABSTRACTS OF JAPAN vol. 6 no. 193 (M-160) ,2 October 1982 & JP,A,57 098449 (HITACHI LTD.) 18 June 1982, see abstract	
A	EP-A-0 189 582 (MASCHINENFABRIK FR. NIEPMANN GMBH & CO.) 6 August 1986 see the whole document	1,9-11
A	EP-A-0 189 761 (JAPAN TOBACCO INC.) 6 August 1986	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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